Airborne Radar Sounding of Lake Vostok

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Airborne radar sounding and laser altimetric mapping of Lake Vostok, a subglacial lake in Antarctica, and portions of the Antarctic ice sheet have been proposed as a part of a joint campaign for NASA Space Sciences and NASA Mission to Planet Earth. Goals of the campaign include (1) geological interpretation of the nature, origin, age and likely locations of biological habitats of the lake, and (2) use of the experience to design an exploration of Europa, an ice-covered moon of Jupiter, and possible Mars exploration. An extension of this work would be a future deployment of a probe into Lake Vostok to gather in-situ data for further analysis and as a precursor to the deployment of a related probe into a putative subsurface ocean on Europa.

Terrestrial science objectives of the proposed experiment are (1) to obtain data on the detailed form of the lake and its shoreline, (2) to resolve geomorphologic details of the lakeshore area, (3) to develop an understanding of the areas with the bulk of the glacial sediment, (4) to search for subglacial areas beyond the lakeshore which have water that was formerly subglacial in the glacial till, (5) to use this information to better understand the nature of the lake, and (6) to determine the ice thickness and the nature of the subglacial interface. The **data acquired would also allow immediate comparisons with planned spaceborne laser** altimeters such as GLAS. Additional objectives are topographic characterization of Mount Erebus, a 3800 m tall phonolitic stratovolcano in whose summit crater is a lava lake, and mapping of the Antarctic grounding line.

Applications to space science are (1) to study the Vostok and nearby environments as a possible test site for a proposed mission or missions to Europa, (2) to evaluate radar sounders for such a mission, and (3) to evaluate sounders for exploration of the nature and distribution of subsurface water on Mars. The Europa mission objectives will involve the deep subsurface exploration of that body, specifically its ice, ocean, and sediment; to acquire basic planetary compositional data; and to search for life or protolife. Such a mission has a number of crucial engineering challenges that will require high- technology instruments to be flown and/or deployed . An instrument package is contemplated that will melt its way through the ice and into the ocean to search for life and to obtain data describing the characteristics of both ice and ocean. All of this instrumentation will benefit from the existence of an appropriate testbed on Earth. Specifically, the determination of radar parameters (e. g., frequency and operating altitude) and communications equipment parameters requires such a study.

The use of terrestrial ice as an analog for Europa is based on strong similarities. In both cases the transmission medium is ice. When cold and pure enough, its complex dielectric constant is small and most energy is transmitted. For both cases the surface ice is cold enough, and in both cases the ice warms with depth, probably warming to the pressure melting point at a few kilometers depth. The subject for study is the purity. Terrestrial ice sheets are astoundingly pure; on Europa the purity is unknown but depends on the effects of tidal warming, which could enhance attenuation or zone-refine the ice to improve purity.

Present models of planetary formation hold that Mars should have had more primordial water than Earth, and that Mars should have outgassed less. However, the present form and location of that water on Mars is not known from direct data. It is believed to exist as water of hydration, adsorbed onto clays in the regolith, or in ground ice at higher latitudes. Ice covers in the Antarctic dry valleys may resemble the martian case, and this experiment will examine the possibility of determining permafrost, wet ice, and underlying water at depth using sounding radar. As in the Europan case, frequencies, altitudes and other parameters need study.

This project will constitute a fundamental increase in glaciological science infrastructure through the development and application of sounding radar capability. While traditional imaging radar is well developed, there have been no sounding radars in space. Early sounding radars were used for ice sheet and subglacial geology studies 20 and 30 years ago, but new techniques have increased the possibilities enormously. These radars are of particular use in the planetary program for both Europa and Mars research. An airborne radar and laser altimeter will be placed aboard an appropriate platform at close to orbital altitude to examine the change in signal return from within the ice. The role of altitude and ice sheet content and geometry in shaping the return, and the certainty with which the surface and basal returns can be separated, will be evaluated. Optimum frequency or frequencies and other parameters will be selected.

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